Photo-ionisation for strontium ion QIP

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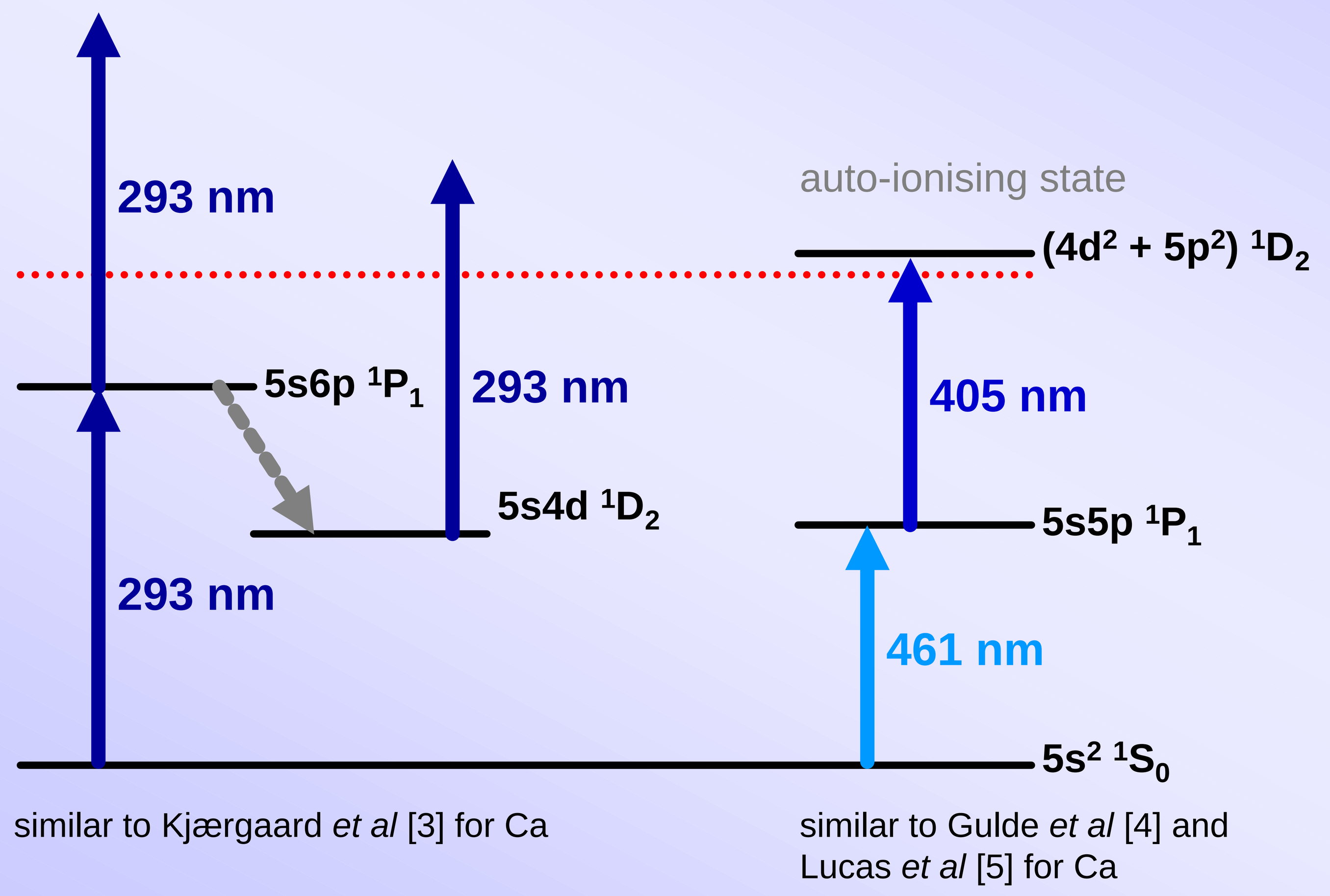
Decoherence

- quantum information experiments with trapped ions require coherence times that are much longer than gate operation times
- motional decoherence is a significant limitation
- large heating rates have been observed in some traps [1,2]
- fluctuating patch potentials on electrode surfaces are thought to be the cause of large heating rates

Resonance-enhanced photoionisation

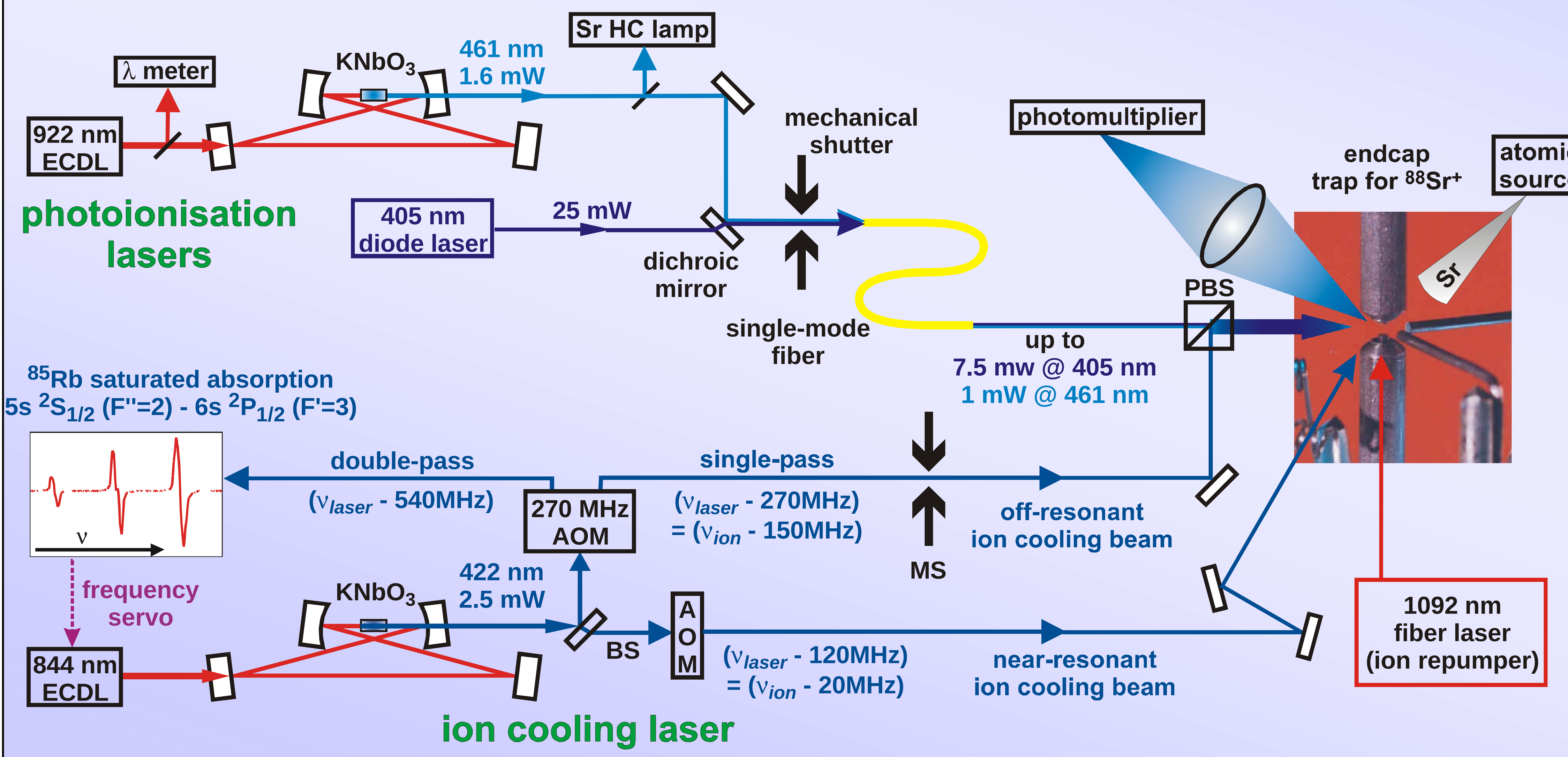
- highly efficient: requires greatly reduced atomic flux
- reduces electrode contamination and patch potentials
- also eliminates build-up of charge on insulating surfaces
- has been demonstrated for Ca^+ ion trap experiments [3-5]

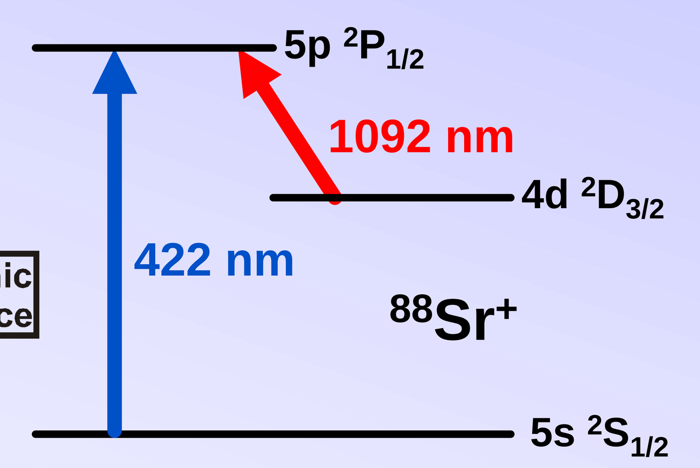
Strontium photoionisation schemes



- preferred scheme is: $5s^2\ ^1S_0 \rightarrow 5s5p\ ^1P_1 \rightarrow (4d^2+5p^2)\ ^1D_2$
- transition to auto-ionising state is around ~1 nm wide [6]

Photoionisation setup

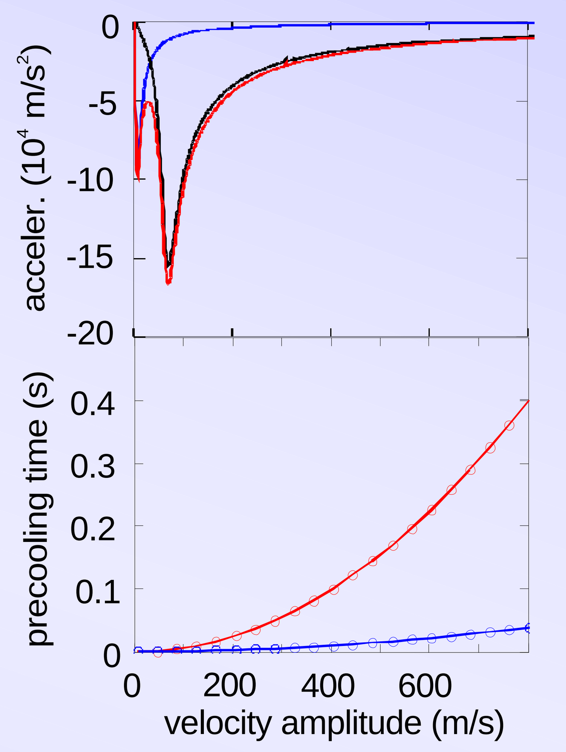




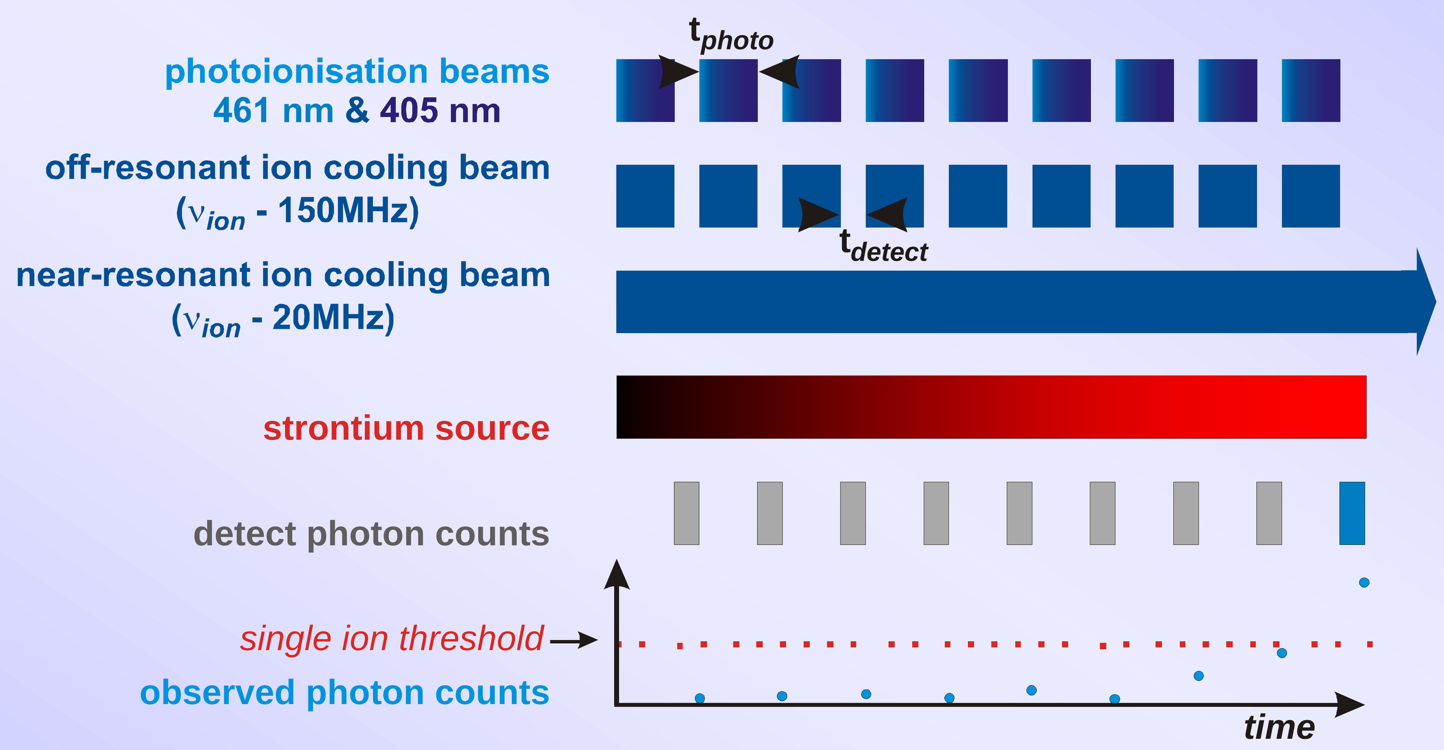
- a hot atom from the strontium source is photoionised by 461nm & 405 nm
- off-resonant 422 nm beam pre-cools the hot ion
- near-resonant 422 nm beam cools the ion close to the Doppler limit, where it scatters photons efficiently and is detected

Precooling efficiency

- simple model accounts for saturation and Doppler-shift in oscillatory motion of ion
- near-resonant 422 nm beam cools the ion close to the Doppler limit, where it scatters photons efficiently and is detected



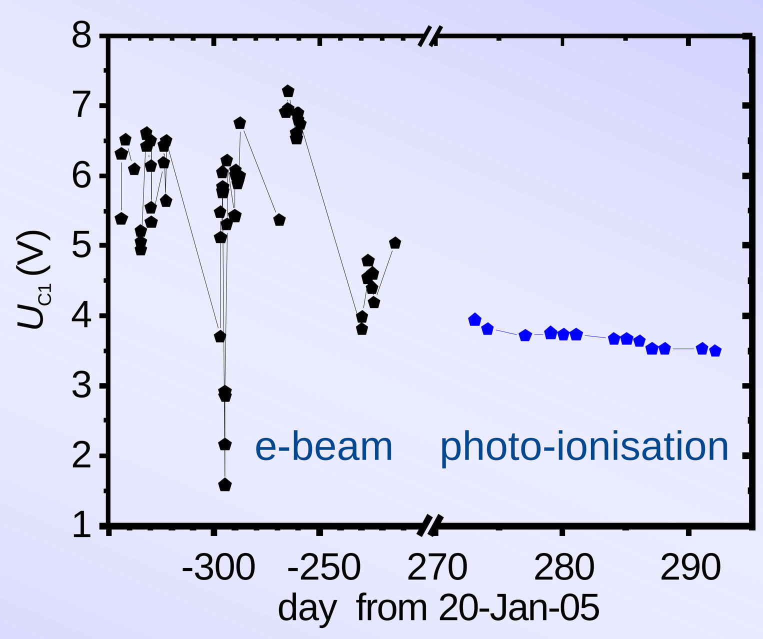
Sequence for precision single ion loading



- modulate between loading/cooling & detection, due to background scatter
- t_{photo} = 70 ms and t_{detect} = 30 ms
- cold ion scatters photons efficiently from near resonant beam for easy detection
- source of atomic flux is switched off when a single ion is detected
- can extend principle to more than one ion for linear traps

Reduced micromotion fluctuations

- instant improvement on fluctuations of micromotion compensation voltages



Photoionisation efficiency

- compare trap loading characteristics of electron impact and photoionisation
- estimate an upper limit to the strontium source temperature using readings from a thermocouple attached to the strontium source

	electron impact ionisation	photoionisation
Loading temperature	~350°C (623K)	~200°C (473K)
Sr partial pressure	~10^{-5} torr	~10^{-9} torr
Observed loading efficiency (#loads / #attempts)	~0.25	~0.9

- conclude that the atomic flux required for photoionisation loading of Sr is at least 10^4 times less than that required for electron impact ionisation

Isotope selectivity

- isotope abundance: 84 (0.56%), 86 (9.86%), 87 (7.00%), 88 (82.58%)
- should be able to load chosen isotopes by ensuring that power and Doppler-broadening of the 461 nm transition is minimised
- 87-88 isotope shift for 461 nm transition is 56 MHz

References

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